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IMAGING THE Al-SiC INTERFACE REGION BY HREM TECHNIQUES

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A metal reinforced with ceramic particles can be of commercial interest because of its improved specific strength. The higher the strength of the interface between the metal matrix and the ceramic particle the higher will be the strength of the metal-ceramic composite. We report on the first results of a high resolution electron microscopic study of such a composite manufactured by Billiton Research (Arnhem). The composite consists of SiC particles in an #6061 aluminium alloy cold pressed from powder and subsequently extruded. It has been investigated on the Akashi 002B transmission electron microscope from Oxford University with a theoretical structural resolution of 0.18 nm at 200 kV. It is imperative that both the metal matrix and the ceramic particle are most accurately oriented in a low index pole and that the interface is parallel to the electron beam and stepless perpendicular to that plane [1]. In figure 1 an example is given in which the basal plane of the hexagonal SiC particle is aligned parallel to the interface. Locally the (200)Al fringes with an interplanar spacing of 0.20 nm are resolved. The angle between these planes and the interface is 54°. A possible preferred orientation relationship therefore is: (0 0 0 1)SiC//(1 1 1)Al;[2 $\bar{1}$ $\bar{1}$ 0]SiC//[1 $\bar{1}$ 0]Al.

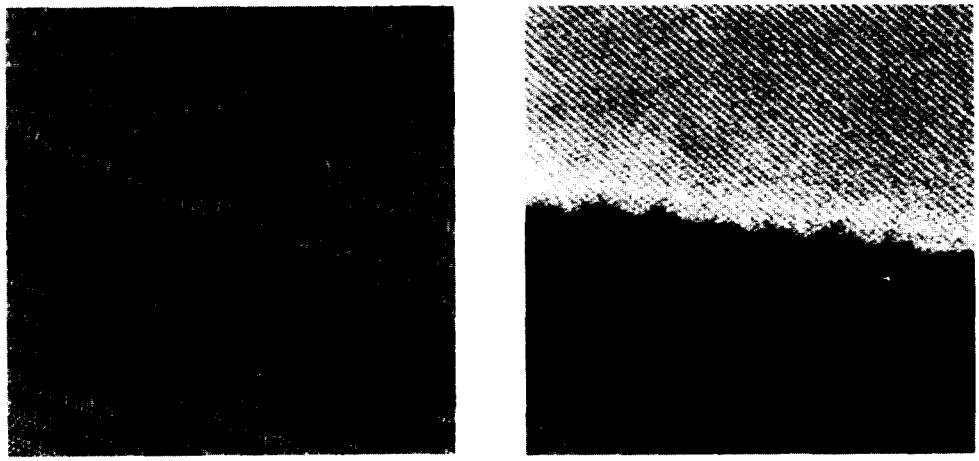
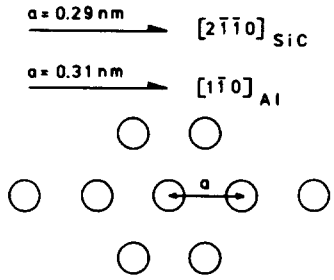


Fig. 1 (Left) Al/SiC composite in which the basal plane of α-SiC is parallel to the interface. The best resolved planes in Al are the (200) planes with an interplanar distance of 0.20 nm and an inclination to the interface of 54°.

Fig. 2 Al/SiC composite in which the basal plane of α-SiC is not parallel to the interface. The best resolved planes in Al are the (111) planes with an interplanar distance of 0.23 nm and an inclination to the basal plane of 70°.

In the case of a non-parallel orientation a stepped interface is observed as is depicted in figure 2. The basal plane is inclined to the interface over an angle of 30°. Clearly visible on this micrograph are the (111)Al planes which make an angle of 40° with the interface. The total angle of 70° suggests the following orientation relationship: $(0\,0\,0\,1)SiC//(1\,\bar{1}\,1)Al;[2\,\bar{1}\,\bar{1}\,0]SiC//[\bar{1}\,0\,1]Al$ with $5d_{111}(Al)=d_{0001}(SiC)$.



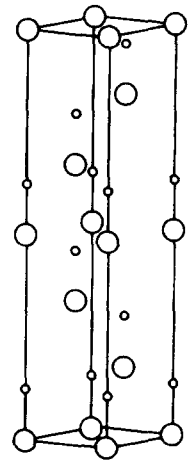


Fig. 3 (Left) Both the basal plane of α-SiC and the octahedral plane of Al are visualized by this sketch of an atomic layer with only the lattice parameter being different for both structures.

Fig. 4 The unit cell of α-SiC with the characteristic CABC'B'A'C stacking spanning a distance of 1.5 nm. The large spheres represent Si, the small ones C.

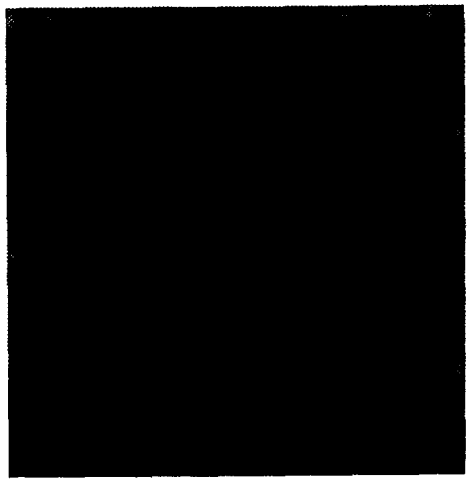


Fig. 5 Simulation of a 15 nm thick α-SiC slab in $[2\,\bar{1}\,\bar{1}\,0]$ orientation with a defocus of 45 nm, a C_s value of 0.4 mm, a defocus spread of 8 nm, and a beam semi convergence of 0.8 mrad.

In both cases the basal plane in SiC is parallel to an octahedral plane in Al. In figure 3 we have sketched those planes exhibiting a total misfit of 6%. This is rather large [2] and will certainly give rise to the formation of dislocations, but they are not resolved in the micrographs. One should bear in mind, however, that because of the large dielectric mismatch between Al and SiC a significant binding can be achieved even in incoherent boundaries. Nevertheless, good lattice matching will lead to smaller separations between the Al and SiC atoms and therefore to an amplification of these image effects. So, epitaxial relations do not preclude this from being the predominant binding mechanism.
In figure 4 we show the α-SiC unit cell. The data form the necesary input for the EMS simulation programme [3]. In figure 5 we show such a simulation for an 15 nm thick slab of a SiC layer in $[2\,\bar{1}\,\bar{1}\,0]$ orientation with the input parameters for the AKASHI 002B. The characteristic CABC'B'A'C stacking is well reproduced.

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